TELLURIUM-H IN INTERSTELLAR DIAMONDS.

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Summary. Analyses of interstellar diamond separates from the Allende meteorite indicate the presence of a Te component consisting essentially of ^{128}Te and ^{130}Te only. The composition of this 'Te-H' is not compatible with the predictions of the neutron burst model [1,2] devised to explain the Xe-H pattern. It is consistent, however, with the basic predictions from the recently suggested timescale model [3], although, in detail, the ^{128}Xe/^{130}Xe ratio is found to be somewhat higher than predicted.

Introduction: The nanometer-sized diamonds abundantly (up to ~1 ‰) present in primitive meteorites are generally regarded as of interstellar origin (cf. [4-7]). This identification is not based on the isotopic composition of its basic element, carbon, but primarily rests on that of the isotopically unusual Xe-HL it carries in a subfraction (approx. 1 Xe-H atom per 10^6-10^7 diamonds), which appears to indicate a connection to type II supernovae [1-5]. Traditionally, the Xe-H part, showing large overabundances of isotopes 134 and 136 has been explained as the result of a 'mini-r-process' [8] or neutron burst [1,2] intermediate between the classical s- and r-processes. However, it has been argued [3] that the contribution of Xe-H to meteoritic Xe - and possibly that of the similar Xe-H* component apparently accounting for ~ 7 % of solar ^{136}Xe [9] - is uncomfortably large for a special process apparently not (yet) required by any other element. For this reason, and because of the inability of the neutron burst model to match the Xe-H composition in detail, an alternative 'timescale model' [3] has been suggested, which relies on the average r-process followed by an early separation of stable Xe end products from r-process precursors that have still to decay. Both, neutron burst and the timescale model make predictions for the isotopic composition of other elements that would be produced at the same time. Tellurium, located in the same mass region as xenon, and on the top of the r-process abundance peak associated with magic neutron number 82, seemed a natural choice to search for a related component.

Experimental. Following what are basically standard procedures now [10] a diamond residue was prepared from the Allende meteorite. Because of its lack of interstellar SiC,

Allende seemed a better choice than, e.g., Murchison, where the possible presence in the diamond separate of fine-grained SiC containing trace elements with s-process signature would have complicated interpretation of the data [11]. The isotopic composition of Te was determined using multi-ion counting thermal ionization mass spectrometry [12]. Several diamond samples of approx. 10^{-2} mg each were directly loaded onto the evaporation filament, Ba(OH)$_2$ on the ionization filament as an emitter, and Te was measured as negative Te$^-$ ions.

Results and Discussion. Representative data are shown in Fig.1 in a three-isotope diagram of $\delta(^{125}$Te/^{128}Te) vs. $\delta(^{124}$Te/^{128}Te). Data shown are block averages (integration time 80 sec.), with the errors (2σ) assigned derived from the number of counts using Poisson statistics. The data points fall on a mixing line joining approximately normal Te with a component that contains virtually no ^{124}Te and ^{125}Te.

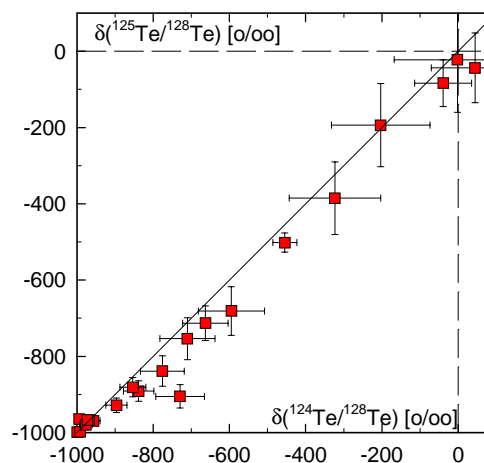Fig.1: 3-isotope plot of δ (^{125}Te/^{128}Te) vs. δ (^{124}Te/^{128}Te) in Allende diamonds. ^{128}Te is used in the denominator because (unlike ^{130}Te) it was measured in each analysis.

Analogous plots for the other light isotopes show that the anomalous component contains essentially no $^{120-126}$Te; it consists only of ^{128}Te and ^{130}Te. Hence the situation in Te is similar to that in Xe in that a component is present which shows strong overabun-

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dances of the two heaviest, r-only nuclides. By analogy, we designate this component Te-H. However, whereas in Xe 'pure Xe-H' has only been seen mixed with some kind of more normal xenon containing s-only nuclides such as ^{130}Xe, in several blocks of our Te measurements virtually 'pure Te-H' is observed. We derive the following composition of the pure component: ^{120}Te / ^{122}Te / ^{123}Te / ^{124}Te / ^{125}Te/ ^{126}Te / ^{128}Te / ^{130}Te = <4x10^{-5} / <0.0012 / <0.0008 / ≡0 / 0.0006±0.0018 / 0.0001±0.0037 / 1.008±0.018 / ≡ 1. This composition (in the form of δ-values) is shown in Fig. 2, where it is compared to the predictions of the two models.
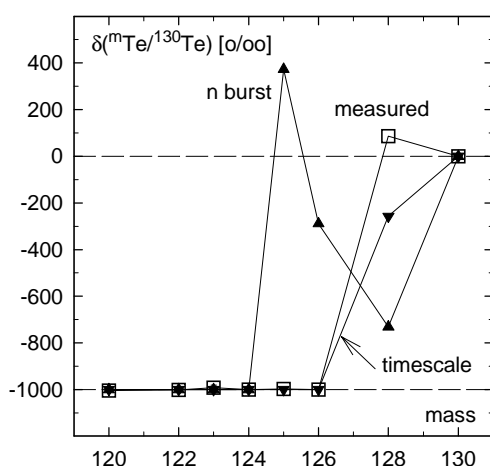

Fig. 2: Te-H composition derived in this work in comparison with the predictions of the n burst and timescale models. Shown are ^{130}Te-normalized δ-values.

The neutron burst model predicts large enhancements of ^{125}Te and ^{126}Te relative to the s-only nuclides 122-124, with the size of the effect (in δ-values) at ^{125}Te even surpassing those at ^{128}Te and ^{130}Te [2]. These are not observed and the discrepancies between the predictions of this model and observations are even more severe in the case of Te than they are for Xe. On the other hand, the data for these isotopes are in agreement with the predictions of the timescale model which, because of the long half-lives of the ^{125}Te and ^{126}Te precursors ^{125}Sb (2.8 a) and ^{126}Sn (10^5 a) predicts extremely small contributions only, which would be too small to be detectable. A discrepancy exists in the ratio ^{128}Te/^{130}Te, however, which is higher than predicted, and even higher than the production ratio in the average r-process as deduced

from the normal ratio of these two r-only nuclides. Because the half-lives of the ^{128}Te precursors are effectively longer than those of the ^{130}Te precursors, this ratio, if anything, should be lower than the production ratio. This question needs to be pursued further both experimentally and theoretically.

A possible solution in the framework of the timescale model is relaxation of the concept of the 'average' r-process. There are indications for component structure in the r-process [13] and diverse supernova sources [14]. Perhaps the products seen in the interstellar diamonds derive from the source(s) primarily responsible for the A~130 abundance peak, differing in relative yields from the 'grand average' r-process.

A rough estimate based on an assumed ion yield in the Te analysis of ~10^{-3} suggests a ^{130}Te-H/^{136}Xe-H ratio that is similar to what both models predict, thus indicating comparably little, if any, elemental fractionation between Te and Xe. This makes precondensation as the mechanism for producing the low observed Ba-H/Xe-H ratio of <10^{-3} [15] (necessary in the neutron burst, but not in the time scale model) rather unlikely. A possible inference is that there should have been no fractionation between Kr and Xe. If this is correct, the low observed Kr-H/Xe-H ratio also suggests that the r-process component responsible for the A~130 peak rather than the grand average r-process should be used as the baseline in the framework of the timescale model.

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